Annex C

Rationale Behind NMFS Approach to Estimation of "D" from PIT-Tag Data

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While the concept of differential post-Bonneville survival for transported and inriver fish is general, the parameter 'D' has a specific meaning, given by the manner in which it is applied in the PATH life-cycle models. There, 'D' is defined as the ratio of two parameters: λ_T, the post-Bonneville survival for transported fish, and λ_C, the post-Bonneville survival for fish that arrive below Bonneville via in-river routes. In particular, the traditional "T:C" ratio of Lower Granite smolt-to Lower Granite adult return rates for the two groups can be expressed as the product of the ratio of juvenile survival from Lower Granite Dam to Bonneville Dam and the ratio of post-Bonneville Dam survival:

$$T{:}C = \frac{SAR_T}{SAR_C} = \frac{V_T\lambda_T}{V_C\lambda_C} = \frac{V_T}{V_C}D\cdot$$

Despite evidence that post-Bonneville survival for transported fish varies depending on the dam from which fish were transported (in particular, fish transported from McNary Dam appear to have lower return rates than those transported from Lower Granite or Little Goose Dam, as discussed below), the PATH life-cycle models assign the same value of λ_T, and hence *D*, to all transported fish, regardless of the dam from which they were transported. Thus, if post-Bonneville survival does vary depending on transport site, the PATH *D* is actually a weighted average of the differential mortality for the various transport sites included in a particular prospective scenario.

(In addition, the PATH models apply the same *D* value to all transported fish regardless of the date which they were released below Bonneville Dam. PIT-tag data from 1995 provide evidence of important seasonal variations in post-Bonneville survival of transported fish. More years of such data are needed).

Moreover, all previous PATH analyses (non PIT-tag) that attempted to estimate *D* were based on transport studies that transported fish from Lower Granite or Little Goose Dams. The resulting estimated *D* values have then been applied to all transported fish in the PATH models. In NMFS' analysis in the previous AFISH draft, our choice to use fish transported only from Lower Granite or Little Goose Dams was in part to be consistent with these previous analyses, and in part because most prospective scenarios involving transportation place heavy emphasis on collecting and transporting fish at the upper dams. The States and Tribes' (STFA) analysis is perhaps the first to attempt to estimate *D* from fish transported from all four transport dams (Schaller et al 1999).

When using data from PIT-tagged fish to estimate parameters for the PATH models, it is important to remember that those models are intended to represent the runs at large, and that PIT-tagged fish are not necessarily representative of nontagged fish in every regard. Especially important in the case of estimating *D* is the fact that the proportions of PIT-tagged fish that experience certain detection histories is vastly different from the proportions of nontagged fish. It was this realization that led to the use of "never detected" PIT-tagged fish as the most proper group to use to represent nontagged fish that remain in the river. PIT-tagged fish that entered collection systems in 1994-1996 were usually returned to the river, nontagged fish in collection systems were transported. (The situation changed beginning in 1997, when many PIT-tagged hatchery fish were purposefully transported from Lower Granite Dam for the Idaho Hatchery PIT-Tag Study). Thus, of fish that remained in the river and survived to Bonneville Dam, a much higher proportion of PIT-tagged fish experienced one or more bypass systems than did their nontagged counterparts.

The same care must be taken to define the group of transported PIT-tagged fish that is to represent transported nontagged fish to estimate *D* for the PATH models. Most PIT-tagged fish were returned to the river at Lower Granite and Little Goose dams. The result is that, comparing transported PIT-tagged and transported nontagged fish, a higher proportion of PIT-tagged fish were transported from lower dams than their nontagged counterparts. To say it another way, nontagged fish were transported the first time they were bypassed; more PIT-tagged fish were returned to the river and “vulnerable” to transportation at lower dams. Estimates of *D* based on PIT-tag data must account for this bias toward lower-river transport among PIT-tagged fish.

The bias was particularly strong in 1994, before McNary Dam was equipped with a slide-gate, so that all PIT-tagged fish bypassed there were transported. Of the total number of PIT-tagged wild yearling chinook salmon (Lower Granite-equivalents) transported in 1994, the proportions transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams were 9%, 7%, 10%, and 75%, respectively (rounding accounts for the total of 101%). In contrast, we estimate roughly the following proportions among transported nontagged fish in 1994: 45%, 15%, 25%, 15%.

The STFA analysis adds together PIT-tagged fish transported from all sites and considers them representative of nontagged transported fish. We estimated return rates for wild PIT-tagged fish transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams of 0.69%, 0.59%, 0.08%, and 0.02%, respectively. The STFA report notes that the choice of inclusion or exclusion of fish transported from Lower Monumental and McNary dams has the greatest influence on the estimate of *D*. This result is almost entirely due to the great difference in return rates for fish transported from various dams in 1994, and the failure of the STFA analysis to properly construct a PIT-tagged transport group representative of nontagged transported fish in that year. Because very few fish, tagged or nontagged, were transported from McNary Dam in 1995 or 1996, the effect is not nearly as big for those years.

Using the assumptions we used in the previous draft, the estimated *D* value was 1.24 for wild yearling chinook salmon in 1994, based only on fish transported from Lower Granite or Little Goose Dam. If we simply added together fish transported from all four transport sites, as was done by STFA, the estimate was drastically changed, to 0.24. However, this estimate was not a valid representation of the PATH-model parameter, because the PIT-tagged transported group was not representative of the run at large. To properly represent nontagged fish, the return rates from juveniles transported from the various dams must be weighted proportionally to nontagged fish transported from each dam (roughly 45%, 15%, 25%, 15%, as noted above).

When this was done, the estimated *D* value for wild chinook salmon in 1994 was 0.82. To make a useful contribution, STFA must redo their analysis, correctly handling fish transported from the lower dams. We suspect the previous NMFS results will not appear as "extreme."

The second most influential alternative in the STFA analysis was the method used to extrapolate empirical survival estimates from the Snake River to the stretch from McNary Dam to Bonneville Dam, where no empirical data could be collected in 1994-1996. NMFS assumed per-project survival was the same in the lower river as in the Snake, while STFA proposed extrapolation based on equal per-mile survival probabilities. Empirical estimates of McNary-to-Bonneville survival are now available for PIT-tagged steelhead in 1997, 1998, and 1999, and for PIT-tagged yearling chinook salmon in 1999. The following table compares each empirical estimate with values extrapolated by the two methods from estimated Lower Granite-to-McNary survival from the same year:

Species/Year	Empirical estimate survival MCN-BON	Per-project extrap.	Per-km extrap.
1997 steelhead	0.651	0.788	0.717
1998 steelhead	0.769	0.729	0.635
1999 steelhead	0.720	0.759	0.679
1999 chinook	0.715	0.839	0.782

For steelhead, per-km extrapolation was more accurate in 1997, per-project was more accurate in 1998, and there was virtually no difference in accuracy in 1999. Both extrapolations overestimated for chinook salmon in 1999; per-project more so. Available empirical data remain too sparse to resolve the question of proper extrapolation method for years before lower-river estimates were available. Perhaps the two methods bracket the reasonable range of possibilities.

The STFA report states that "more data are unlikely to perfect our understanding of 'D' or eliminate the uncertainty in the most influential assumptions." This statement does not follow from the conclusions presented in the STFA report itself and is easily refuted: the report notes that the two most influential assumptions on *D* estimates are (1) whether or not PIT-tagged fish transported from Lower Monumental or McNary dams are included in the "transport" group; and (2) the method used to extrapolate survival estimates to the McNary-to-Bonneville stretch. This document demonstrates that (1) is not really an uncertainty about assumptions, but about the proper way to use PIT-tag data to represent the relevant groups in the PATH life-cycle models. This document also shows how this "not likely resolvable" uncertainty is solved. Influential, "unresolvable" assumption (2), has also already been resolved by continued development of the PIT-tag detection system, so that extrapolation to the lower river is no longer necessary. For juvenile steelhead migrations beginning in 1997 and yearling chinook salmon migrations beginning in 1999, empirical data are the basis of the McNary-to-Bonneville survival estimate.

The PIT-tag system continues to develop, along with our understanding of post-Bonneville survival and how to investigate it with PIT-tag and other data. Ongoing direct experiments directed to resolve remaining uncertainties surrounding D are indeed the key to answering the age-old question "Does transportation work?"

Literature Cited

Schaller, H. and 7 other authors. 1999. An analysis of differential delayed mortality ('D') experienced by stream-type chinook salmon of the Snake River: A response by State, Tribal and USFWS technical staff to the 'D' analyses and discussion in the Anadromous Fish Appendix to the U.S. Army Corps of Engineers' Lower Snake River Juvenile Salmonid Migration Feasibility Study. Draft dated August 12, 1999.